

REMARKS

Section A lists the status of the claims. Sections B and C respond to the rejections of the office action of February 28 in the order in which they appeared.

A. Status of the Claims

Claims 1-62 are pending in the application. Claims 1-6 are withdrawn. Claims 8-10, 14-21, 31, 33-42, 47-53, and 62 were rejected under 35 USC 103(a) as being unpatentable over Lee et al., US Patent No. 6881994 and Voutsas, US Patent No. 6,383,899.

Claims 22-29 and 54-61 were rejected under 35 USC 103(a) as being unpatentable over Lee et al. and Voutsas in view of Park et al., US Patent No. 6,727,514.

Claims 8, 14, and 53 are cancelled in this response.

B. 35 USC 103(a) Rejections: Claims 8-10, 14-21, 31, 33-42, 47-53, and 62

Claims 8-10, 14-21, 31, 33-42, 47-53, and 62 were rejected under 35 USC 103(a) as being unpatentable over Lee et al., US Patent No. 6881994 and Voutsas.

Claim 8 has been cancelled. Claim 9 has been amended include the limitations of claim 8, from which it formerly depended.

As amended, claim 9 recites a method for crystallizing a polysilicon layer on a wafer, the method comprising: forming a first amorphous silicon layer; selectively introducing a crystallizing agent on the amorphous layer in a substantially symmetric pattern in two dimensions; and annealing the wafer to form the crystallized polysilicon layer, wherein substantially no amorphous silicon remains between silicon grains in the polysilicon layer wherein the crystallizing agent is silicon nuclei, wherein the step of selectively introducing a crystallizing agent in a substantially symmetric pattern

comprises: forming a mask layer on the first amorphous silicon layer; etching holes in the mask layer, the holes distributed in a substantially symmetric pattern and exposing portions of the first amorphous layer; and depositing silicon nuclei on the mask layer and the exposed portions of the first amorphous layer.

The Examiner finds these elements in Lee et al., except:

Lee et al. do not show using germanium or silicon as the crystallizing agent. Voutsas teaches to use either silicon or germanium as crystallizing agents so as not to adversely affect the electronic properties of the silicon layer. It would have been obvious to a person of ordinary skill in the art at the time of invention to use either silicon or germanium as crystallizing agents as taught by Voutsas in the process and device of Lee et al. so as not to adversely affect the electronic properties of the silicon layer.

Applicants will respectfully point out, however, that the claim recites that the crystallizing agent is introduced by *depositing silicon nuclei on the exposed portions of the first amorphous layer*.

Voutsas, however, does not teach deposition of silicon nuclei *on* amorphous silicon. Rather, Voutsas teaches *implantation* of silicon or germanium ions, at preselected energies, *into* amorphous silicon (col. 5, lines 44-51).

In the claim, silicon nuclei are deposited, settling on a surface as they form; in Voutsas, silicon ions are implanted, in a high-energy step, into the amorphous layer, penetrating into the layer, and altering its crystal structure. The different method of introduction of the silicon ions of Voutsas is not incidental. Implantation, at selected implantation energy, is central to the crystallization mechanism employed by Voutsas.

Voutsas apparently teaches 1) forming microcrystals by a pre-anneal, 2) implanting silicon ions, and finally 3) a post anneal (col. 3, lines 37-53). After the pre-anneal, there are microcrystals among amorphous (noncrystallized) regions (col. 3, lines 38-42.) The implantation step of Voutsas serves to break the weak bonds between silicon

atoms in the amorphous phase, inciting these silicon atoms to bond to the microcrystals formed during the pre-anneal (col. 6, lines 7-19.) At appropriate implantation energy, *implanted* silicon ions have sufficient energy to break weak bond between silicon atoms in the amorphous phase.

Silicon nuclei deposited on an amorphous silicon layer, however, do not penetrate into the amorphous silicon layer, and will not break bonds between silicon atoms. Deposition, as recited in the claim, does not give silicon nuclei the energy required to break silicon bonds.

In short, the method of Voutsas requires *implantation* of silicon ions; Voutsas does not teach *deposition* of silicon nuclei, as recited in claim 9.

Claim 10 further recites forming a second layer of amorphous silicon *on and in contact with* the first amorphous silicon layer and the silicon nuclei.

Applicants cannot find, in Lee et al., a second amorphous silicon layer deposited *on and in contact with* the first amorphous silicon layer. An additional amorphous silicon layer may be deposited above the first silicon layer, but this additional silicon layer is nowhere taught as being on and in contact with the first layer.

Independent claims 31, 33, 47, and 62 similarly recite a second amorphous silicon layer on and in contact with the first amorphous silicon layer; thus their dependent claims 34-36 and 48-49 also include this limitation.

Claim 14 has been cancelled. Claim 15 has been amended to include the limitations of claim 14, from which it formerly depended.

As amended, claim 15 recites a method for crystallizing a polysilicon layer on a wafer, the method comprising: forming a first amorphous silicon layer; selectively

introducing a crystallizing agent on the amorphous layer in a substantially symmetric pattern in two dimensions; and annealing the wafer to form the crystallized polysilicon layer, wherein substantially no amorphous silicon remains between silicon grains in the polysilicon layer wherein the crystallizing agent is laser energy wherein the step of selectively introducing a crystallizing agent in a substantially symmetric pattern comprises treating the first amorphous layer with a laser at locations distributed in a substantially symmetric pattern. Claim 50 has a similar limitation.

Lee et al. do not teach applying laser energy to an amorphous silicon wafer in a substantially symmetric pattern in two dimensions. The embodiments of Lee et al. (Fig. 65, for example, and col. 45, line 59-col. 46, line 48) that describe selective introduction of a crystallizing agent (in "crystallization windows") teach, for example, the use of transition metals or transition metal silicides as crystallization catalysts (col. 46, lines 13-15), but do not teach the use of laser energy applied through these windows.

Claim 37 recites a method for maximizing grain size and controlling density of grain boundaries in crystallized silicon, the method comprising: forming a first amorphous silicon layer on a wafer; selectively creating nucleation sites at substantially uniform intervals on the first amorphous silicon layer; annealing the wafer to convert the amorphous layer to polysilicon; and forming a plurality of memory cells in the polysilicon, wherein portions of the cells comprise portions of the polysilicon, and *wherein placement of the nucleation sites and placement of individual memory cells is not coordinated.*

The Examiner has not specifically identified such a teaching in Lee et al.

Applicants will point out, however, that in the embodiment of Lee et al. describing use of

a crystallization window, there is a specific teaching that word lines are formed over the regions where the crystallization windows were formed, and that channel regions of the TFTs (the memory cells) are located below the word lines (col. 46, lines 44-47), i.e. that placement of memory cells and placement of nucleation sites in fact *are* coordinated.

Another embodiment of Lee et al. employs metal-induced crystallization from seeding sites, or seeding windows (col. 68, line 29-col. 69, line 43). In this embodiment, however, Lee et al. also teach coordination of placement of the nucleation sites and memory cells (col. 69, lines 41-43):

Formation of devices in the region of the seeding windows 5424 should be avoided due to excessive transition metal contamination.

Claim 53 has been cancelled.

Applicants have shown that Voutsas does not teach deposition of silicon nuclei. Lee et al. do not teach laser crystallization at uniform intervals, nor do Lee et al. teach formation of memory cells in a crystallized layer where placement of the memory cells is not coordinated with placement of nucleation sites. Applicants respectfully request withdrawal of the 35 USC 103(a) rejection of claims 9-10, 15-21, 31, 33-42, 47-52, and 62.

C. 35 USC 103(a) Rejections: Claims 22-29, 54-61

Claims 22-29 and 54-61 were rejected under 35 USC 103(a) as being unpatentable over Lee et al. and Voutsas in view of Park et al.

Claim 22 recites a method for producing a wafer having a crystallized silicon layer with controlled defect density, the method comprising: forming a first layer of amorphous silicon on the wafer; selectively introducing a crystallizing agent on the amorphous silicon layer in a substantially symmetric pattern across a seeded area; and

annealing the amorphous silicon layer, wherein, after the annealing step, in the seeded area, an area bounded by adjacent nucleation sites encloses no more than five crystal grain boundaries.

The Examiner points to Fig. 1 (for example, Fig. 1(c) and 1(d)) as evidence that the area bounded by adjacent nucleation sites encloses no more than five crystal grain boundaries. It is true that in Fig. 1(c) only four grain boundaries are shown in the area bounded by any four adjacent nucleation sites. This is because only the crystallized regions 107 surrounding each nucleation site are of interest to Park et al., and only the grain boundaries of crystallized regions 107 are shown.

Applicants will maintain, however, that, referring to Fig. 1(c), one skilled in the art will appreciate that region 111, between crystallized regions 107, will have multiple grain boundaries which are not shown. As Park et al. describe (col. 7, lines 58-62), regions 111 are either amorphous or polycrystalline. In either case, there will be multiple additional grain boundaries in each of these regions. These grain boundaries are not shown because they are not important to the invention of Park et al., as Park et al. only teaches formation of TFTs within the boundaries of crystallized regions 107, as in Figs. 4(a) and 6(a) of Park et al.

As described in paragraphs [0062] and [0063] and accompanying Figs. 4a and 4b of the present application, the only way to guarantee that there will be no more than five grain boundaries in the area bounded by adjacent nucleation sites is to continue crystallization until the grain boundaries of adjacent crystallized regions meet, leaving no region like amorphous or polycrystalline region 111 of Park et al. There is no teaching in Park et al., however, that crystallization continues until the *entire* amorphous silicon layer

is included in crystallized regions 107; in fact Park specifically shows and refers to regions 111 *between* and not included in crystallized regions 107. Thus there will be more than five grain boundaries in the area of Park et al. bounded by adjacent nucleation sites.

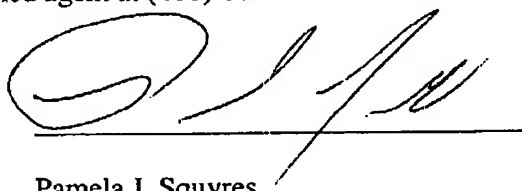
Applicants have shown that the suggested combination of Lee et al., Voutsas, and Park et al. does not teach each and every limitation of claims 22-29 and 54-61, and thus respectfully request that the 35 USC 103(a) rejection of these claims be withdrawn.

CONCLUSION

In view of the preceding Remarks, Applicants submit that this application is in condition for allowance. Reconsideration is respectfully requested. If objections remain, Applicants **respectfully request an interview**. In the event that objections remain, the Examiner is asked to contact the undersigned agent at (408) 869-2921.

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Date



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